Data Acquisition and Analysis System Technical Specification

1. Scope: The Data Acquisition and Analysis System (DAAS) to be furnished will be used as a comprehensive data acquisition, processing and analysis suite that will enable testing and development of diagnostic and prognostic instrumentation, sensor and sensor technologies, and software/algorithms.

The system will interface with existing Microdot/BNC sensor cabling, and sensors, including ICP/voltage mode accelerometers, and will be utilized in conjunction with a test cell. The test cell will consist of a machinery fault simulator with the capability for insertion of various faults and fault severities, and testing of a variety of machinery component types (pumps, fans, gearboxes, belt drives, centrifugal/reciprocation machinery). The DAAS will also be modular, portable, and versatile for use on various rotating machinery on land-based test sites, surface ships, and submarines.

2. DAAS Hardware Requirements:

a. The DAAS will meet the following hardware requirements:
   1. 80 input channels able to be separated to two independent systems with 40 channels each
   2. Supports direct transducer coupling for voltage and ICP sensors
   3. Supports TEDS transducers
   4. Hardware compatibility with existing/in-house data acquisition system
   5. Sample rate up to 204 kHz
   6. Simultaneous throughput to host PC disk while processing (FFT, order track, third octave)
   7. Support for conditioning and tracking of at least 4 tachometers
   8. Software controlled channel setup with hardware LED indicators
   9. Chassis configurations flexible to include 16-slots (up to 64 channels) with ability to daisy chain the chassis for larger channel count requirements. All cards to be interchangeable between chassis
   10. System will be provided with a portable controller with the same or better features as follows: Pentium-4 2.6 GHz processor, 512 MB RAM, 80 GB Hard disk Drive, 15 inch display, CD/DVD burner (DVD+RW/+R), weighing less than 10 pounds, with carrying case
   11. Must include 2 ruggedized shipping cases each able to be fit through a 26 inch diameter hatch and not exceed 3 feet in length
   12. Each shipping case will be capable of housing all hardware associated with a 40 channel system
   13. The shipping case and all hardware associated with a 40 channel system will not exceed 100 pounds

b. The DAAS must also have the following expansion capabilities:
   1. Expandable up to 960 input channels
   2. Support for direct transducer coupling, including charge, strain and microphone
   3. Simultaneous throughput to host PC disk while processing (real-time third octave)

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3. DAAS Software Requirements:

a. The DAAS will meet the following data acquisition software requirements:
   1. Direct access to any ODBC database for transducer information
   2. Software and binary data compatibility with existing/in-house data acquisition system
   3. Embedded, user-specified, documentation
   4. Channels can be grouped into vibration, acoustic, static and tachometer channels
   5. Support for multiple reference channels
   6. Averaging methods include stable averaging, exponential averaging, Maximum hold and Minimum hold
   7. Following functions are provided online: Time, Spectra, FRF (H1,H2, Hv), Octave (1/1, 1/2 1/3, 1/6, 1/12, 1/24) - optionally with ANSI emulation, Cross-Power, Auto-Power, and Sound Intensity. FRF's and crosspowers are calculated between responses and all reference channels.
   8. Following functions are provided online referenced to at least two different tachometers: Octave sections (1/1, 1/2 1/3, 1/6, 1/12, 1/24), Order Sections, Frequency Sections and Critical Band sections, overall levels.
   9. The following can be calculated post-processed from at least two different tachometers: order sections, octave sections, critical band and frequency sections, weighted overall levels, maximum order contributions, peak order or peak frequency hold, integration or differentiation, average of all functions between different runs.
   10. Simultaneous throughput to host PC disk while processing (FFT, order track, real-time third octave)
   11. Vibration channels can be converted online to displacement/velocity/acceleration for spectra and autopower functions
   12. User-configurable display layouts with 2D (Front/Back, Upper/Lower, Octave, Bode), waterfall and colormap displays
   13. Single, double, harmonic, ratio and crosshair cursors
   14. Change cursor properties, annotation style, amount of decimal places
   15. Support for embedding of data in Microsoft documents (e.g. Word, Excel, Powerpoint) using Active Pictures

b. The DAAS data acquisition software must also have the following expansion capabilities:
   1. Expandable up to 960 input channels Simultaneous throughput to host PC disk while processing (FFT, order track, third octave)
   2. Batch Reporting and Plotting
   3. Capability to network or float the software to other PC compatible systems

c. The DAAS Real Time Data Processing software must have the following features/capabilities:

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1. Data I/O - Direct support of binary digital time history data file (TDF).

2. Displays/Plotting:
   (a) Static Display (2D-3D Functions): Front/Back, Upper/Lower, Nyquist, Octave, Waterfall, Color Map: link of time and frequency cursors/selected segments with other displays/forms through software bus.
   (b) Geometry Display: Front/Back, Upper/Lower, Quad, Left/Right
   (c) Strip Chart Display: Multi-channel, Overview, Detailed (zoom), Indicators (Meter, Digital, Bar) with user definable alarm levels and functions (RMS, MAX, MIN, Cursor Value,...), Auto-tailing, Segment and Cursor selections, user definable markers (point or segment). Automatic scrolling
   (d) Powerful plot-format editor allows user definable plot formats (any type/combination of windows, drawing capabilities, text annotation, inclusion of color bitmaps/logos) interactive, automatic and batch plotting modes; automatic reduction for large time histories.

3. User Attributes/Markers:
   (a) All time history data can be complemented with (any number of) user definable attributes of following types: float, integer, string, ordinate (start, increment, rate), variable length (eg. extra data dump).
   (b) User attributes are stored with data in the same file: can be consulted at any moment.
   (c) User Attributes can be defined on the level of the TDF (multiple channels) or the recording (one channel).
   (d) Markers: point or segment markers can be graphically set for identifying specific events/segments. Markers view: 6 color, 3 line styles, 3 thickness.
   (e) Markers editing: cut, copy, paste, move, duplicate, modify, add, key code, description.

4. Editing:
   (a) Icon driven graphical editing, single- or multi-channel
   (b) Editing operations: undo, cut, copy, truncate, duplicate, insert at cursor, overwrite at cursor, replace segment, modify segment (offset, mean, scale, rms, replace by constant, replace by curve), mute, straighten
   (c) Fading: none, linear, 1/2 cosine, power, mute for user definable duration.

5. Trace Manipulation:
   (a) Align, Multiplex and De-multiplex, Mix, Revert, Compose
   (b) Interpolate: spline, polynomial, sinc
   (c) Digital re-sampling: up/down, any new frequency or ratio, configurable anti-alias filtering
   (d) Trend removal
   (e) Curve fitting

(f) Moving and Exponential Average

6. Trace Analysis:
   (a) Conversion of pulse-train(s) to rpm or angle trace with user definable: # pulses, transmission, cross-level, upper/lower tolerances, hold-off %, up-sampling and equidistant interpolation
   (b) Envelope analysis based on Hilbert transform
   (c) Sine Analyzer: amplitude, phase, frequency and sampling speed
   (d) Sine Calibration: dB/Lin, multi-channel
   (e) Quick single value statistics: min (x,y,index), max (x,y,index), mean, rms
   (f) Histogram: standard, cumulative, probability, density, normalization

7. Trace Mathematics:
   (a) Any mathematical expression (+, -, *, ÷) between traces and/or scalars, all provided in a trace calculator.
   (b) Integration: time domain (trapezium, Simpson, four point & Bode), frequency domain.
   (c) Differentiation: time & frequency domain.

8. Trace Generation:
   (a) Signal generator: sine, sweep, saw-tooth, square, random noise, controlled oscillator (with user definable carrier frequency and amplitude; fixed and variable frequency and phase deviations)

9. Audio Feedback:
   (a) All time history data can be played back through the multi-media outputs of the HP9000 workstation or Windows NT PC (16 bit, CD quality)
   (b) Replay of segment or starting at cursor through internal speaker or external headphones/speaker system.

10. Frame Statistics:
    (a) Statistic evaluation on multi-channel time histories: frame length in samples or seconds, overlap in %, samples or seconds.
    (b) Statistical functions: min, max, range, extremum, sum, mean, variance, skewness, kurtosis, standard deviation, rms, crest factor, mean absolute deviation, extreme deviation, Markov regression, 10th-25th-75th and 90th-percentile, median, integration.

11. Spectral Processing:
    (a) Any spectral function on complete/segments multichannel time histories, with logging of processing history.
    (b) Spectral Functions: DFT, FFT, Maximum Entropy Method (MEM), autopower, multiple input multiple output (MIMO) crosspower, MIMO FRF, impulse response, MIMO coherence, principal component analysis

(PCA), autocorrelation (time & frequency domain), crosscorrelation (time & frequency domain), 3D spectral map, 3D MEM map.

(c) Processing parameters: any block size (no limit on size), format (linear. power or power spectral density - PSD), scale (peak, RMS), window (Uniform, Hanning, Hamming, Kaiser-Bessel, flattop), weighting (A, B, C, D)

(d) Optional Time Variant Frequency Analysis (Wavelets, Wigner-Ville)

12. Digital Filtering:
    (a) FIR: Window, Multi-window, Remez
    (b) IIR: Bessel, Butterworth, Chebyshev, Inverse Chebyshev, Cauer, Inverse design.
    (c) Arbitrary FRF
    (d) Graphical definition of cut-off frequencies through single and double cursors.
    (e) Direct graphical interpretation of filter frequency response function FRF, phase and group delay.
    (f) Capability of grouping different filters in one filter with user definable name.
    (g) Multiple filters (software regulates ideal cascading) can be set for filtering multiple channels at the same time.
    (h) Filter modes: direct, zero-phase.
    (i) User-designed filters can be saved in user-definable defaults for later use.
    (j) Octave Filtering: ANSI-IEC compliant 1 and 1/3 Octave filtering (multiple bands in one run). - Harmonic Tracking (Kalman fixed frequency and order filtering)

13. Counting:
    (a) Range-pair, Extremum, Level crossing, mean, range, range-pairmean, range-pair-range

14. Customization:
    (a) A snap-shot function allows the user to define specific layouts and save specific processing parameters for a specific processing tasks. Multiple snap-shots can be saved under different names and recalled whenever required. The snap-shot function exists for : Digital Filtering, Frame Statistics and the main Time Data Processing layer.
    (b) Configurable menubar and ICON toolbar: the user can configure the menu entries, as well as ICONS in the processing toolbar, which will start a specific command or a user program.
    (c) A special mechanism (basename & context) allows the system to be configured for specific tasks. In this way user interface and processing options will depend on the type of task one will have to perform; eg. one can have a set-up for analyzing one type of test article, and a totally

different one for a different type of test article with different defaults, options etc... .

(d) Complete customization and application development capability including the ability to generate user-defined GUI's with different menus which include push buttons, radio buttons, input fields, progress indicators

d. The DAAS Real Time Data Processing software must have the following expansion capabilities:

1. Data I/O
   (a) Instrument recorder interfaces (optional): SONY PC200 Series, SONY SIR-1000, TEAC RD and RX Series, RACAL-HEIM DataRec Series, Audio DAT & Head Acoustics HDR-IV, OPTIM MEGADAC, Metrum RSR-512, RACAL Storeplex range, A480, RACAL HEIM
   (b) File Translators (optional): MTS RPCIII™, nCode nSoft DAC™, HP SDF™.

2. Trace Manipulation:
   (a) Adaptive re-sampling from any reference domain to any reference domain and back again (e.g. resample using engine RPM to angle domain)

3. Spectral Processing:
   (a) Optional Time Variant Frequency Analysis (Wavelets, Wigner-Ville)

4. Digital Filtering:
   (a) Harmonic Tracking (Kalman fixed frequency and order filtering)

5. Block Data Processing:
   (a) In addition to the menu driven processing, the same and many more functions are available in command mode and user programming. These allow manipulation of time history traces, as well as results blocks (spectra, histograms, waterfall maps, etc...).
   (b) Macro-based autosequences can be developed for automatic sequential processing.

e. The DAAS software must provide Advanced Customization capability via Native Microsoft Windows automation support allowing connection between the host data acquisition software and external programs making it possible to customize, extend, automate or integrate user defined programs and features with host data acquisition software. External programs can control host data acquisition software or can be embedded within host data acquisition software.

1. The Advanced Customization capability must accommodate the following system usage scenarios:

(a) Directing Testing Acquisition- Workbooks can be driven from external programs, which is very useful for customization or automation.
(b) Monitoring Testing System - Events and measurement values can be continuously monitored from within an external application thus allowing remote monitoring. Also, the event generated at the end of a measurement can be used to trigger another process, such as notifying the operator.
(c) Analysis extensions – Applications can be extended with in-house algorithms that can take data directly from the acquisition system without having to export to an external file. Results can then easily be fed back to the acquisition analysis software for display, storage or further processing.
(d) Integration with other software – Through Microsoft Windows automation, the acquisition software should be able to integrated with external programs, for instance a control system, where either of the two systems can act as the master or slave system. It is also possible to host ActiveX components inside the software user interface. In this way, control of external devices can be integrated very closely within the acquisition and analysis software, while still being a separate process.

4. Technical Data Requirements:

a. All software provided must include installation CDs
b. All necessary Technical manuals that describe operation, maintenance, troubleshooting, repair and calibration must be included
c. The initial calibration will be performed by a calibration laboratory that is certified to be in compliance with ANSI/NCSL Z540-1-1994
d. Certificates of calibration must be provided